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ABSTRACT

This paper discusses the implications of research regarding the general components of reading and their effects on content reading in grades 7 through 12. Sections deal with such comprehension components as vocabulary, sentence and paragraph structure, reading rate, and purpose setting, as well as comprehension needs in the content areas. Techniques for developing vocabulary, increasing awareness of sentence and paragraph structure, and identifying purposes and rates of reading as well as techniques for teachers to use in facilitating student reading comprehension are included. (DF)

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READING COMPREHENSION IN THE CONTENT FIELDS

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There is considerable evidence in educational research to show that many young people with average intellectual ability in grades 7-12 have difficulty understanding their content area textbooks (Janz and Smith, 1972; Kennedy, 1974).

Some of the difficulty relates to factors such as vocabulary, and sentence/paragraph complexity (Guthrie, 1972). In addition to these factors, research has identified rate of reading, and the purpose for reading as components which also affect comprehension. It is the intent of this monograph to deal primarily with these general components of comprehension, those affecting specific content areas, and to offer suggestions for translating research findings into classroom practice.

Comprehension

Comprehension has been defined by Webster as the capacity for understanding. This capacity, when it pertains to reading, is influenced by such factors as vocabulary, sentence structure, rate of reading, and purpose setting (Palvak, 1974). The content area teacher also has an influence on reading comprehension. It is the teacher's sensitivity to the demands of the content material combined with an understanding of the reading task, from the reader's point of view, that simplifies or complicates reading comprehension.

Investigators have attempted to isolate critical reading factors from other comprehension factors, but with little success. They concluded that the vocabulary measure is a distinct factor, but other skills in comprehension could not be separated from a common comprehension factor (Hunt, 1957; Maney, 1958; Sochor, 1958).

Vocabulary

Vocabulary is the key to comprehension, particularly at the secondary level. This was noted by Conant (1942) when he constructed tests to measure skills in comprehension. The results of the data confirm the usual finding that word

knowledge constitutes a very important fundamental element of comprehension in reading.

Vopni (1955) attempted to determine the influence of extensive vocabulary training upon reading achievement in content areas. The study included words for each content subject taught. Vopni concluded that reading competence was significantly improved when there was a school-wide emphasis on the vocabulary problems in all areas of the curriculum.

Jackson and Dizney (1963) studied the efficiency of an intensive vocabulary program upon the achievement of 12th grade college-preparatory English students. Of the two groups of students involved in the study, there was a significant difference between the experimental intensive vocabulary group and the content group, favoring the former, on vocabulary scores.

The interrelationships between general and specialized vocabulary and reading abilities were investigated by Cooper (1955). From his investigation, Cooper concluded that various measures of vocabulary, general and specialized vocabularies, associated with particular subjects were very highly interrelated. There was a trend for achievement in a subject area to be most highly associated with its own specialized reading ability and vocabulary.

The effect of children's vocabularies on reading comprehension was investigated by Scheck (1964). To explore this relationship, she investigated the children's knowledge of single and multiple meanings of words. Based on her study, Scheck concluded that there was a substantial relationship between the ability to comprehend reading content and vocabulary knowledge of both single and multiple meanings of words.

Sentence/Paragraph Structure

Researchers have explored the ways in which words are put together to form phrases, clauses, sentences, and paragraphs in an effort to ascertain the effect

on reading comprehension. Along with assessing the effect of sentence and paragraph structure on comprehension, some research has been concerned with teaching structural awareness.

Edwards (1969) was interested in the relationship of syntactic variables to comprehension. Her study concentrated on: the position of the relative clause in the sentence, structure of the independent clause, and structure of the relative clause. Edwards' study found that relative clause position, independent clause structure, and relative clause structure all affected comprehension scores. Edwards interpreted this finding to mean that a sentence with its relative clause appearing second and its independent clause in passive form was easier to understand than a sentence with its relative clause appearing first and its independent clause in active form.

O'Donnell (1963) was interested in the relationship between ability in reading comprehension and knowledge of grammatical structure. Specifically, he was concerned with the question of whether there is a higher correlation between reading comprehension and awareness of structural relationships of words in sentences than there is between reading comprehension and ability to verbalize grammatical rules and terminology. His findings support the contention that there is a higher correlation between reading comprehension and the ability to recognize structural relationships of words in sentences than the correlation between reading comprehension and the ability to verbalize knowledge of terminology and rules.

Reed (1966), like O'Donnell, was interested in the relationship between knowledge of sentence structure and reading achievement. Her study with students in English classes attempted to determine the relative effect of the study of syntax and paragraph structure on reading comprehension of monolingual and bilingual pupils of middle ability in grade seven. Her findings show that the students in her experimental group who studied sentence elements and paragraph structure made

significant gains in literal comprehension of sentences and paragraphs when compared with the control group.

Williams and Stevens (1972) sought to determine the effectiveness of teaching methods in the skills of summarizing the main idea and finding the topic sentence. Elementary and secondary students were given exercises in identifying topic sentences and writing appropriate titles for suitably graded workbook paragraphs. Topic sentences appeared at the beginning, middle, and end of the chosen paragraphs. At the secondary level, students were able to determine approximately 57% of the topic sentences and 65% of the titles. Paragraphs in which the topic sentence appeared in the middle seemed to be most difficult for the secondary students.

Tomkowicz's (1959) study focused on the value of direct teaching of selected paragraph patterns in the improvement of reading comprehension at the eighth grade level. The experiment contributed evidence that the direct teaching of paragraph patterns was of some significant value in the improvement of reading comprehension at the eighth grade level.

Rate of Reading

Research pertaining to the rate of reading and its relationship to comprehension may be characterized as inconclusive. Albert J. Harris (1968) found that the degree of correlation between the two areas ranged from low negative to high positive. Rauch and Weinstein (1968) indicate that the relationship between reading rate and comprehension depends upon four factors: the reader's background of experience; the difficulty of the reading selection; the type and difficulty of the questions used to check comprehension; and the reader's purpose.

Lackman (1970) was interested in studying four conditions of prequestions upon comprehension and rate. He was also concerned with the effects of certain prequestion conditions on the ability to answer questions. Lackman found that: the purpose for reading influenced the rate of reading; the mean reading time for

students who had to select and defend their prequestions choice was significantly faster than most other treatment conditions used; the nature of the question (relevant or incidental) had a significant effect upon comprehension scores.

Purpose Setting

Purposeful reading is a major factor in effective comprehension. The studies conducted on questioning and its effect on comprehension focus on two areas: the relationship of the type of question to the retention of the material read, and the placement of questions.

Rothkopf and Bloom (1970) attempted to determine whether the asking of adjunct questions by a teacher could promote more effective study of written instructional materials than written adjunct questions embedded in the text. The results of the experiment showed that the oral and written questions presented at planned intervals in the text resulted in higher learning performance than reading without questions. The effect of the social contact, oral questions on learning performance was found to be significant.

Rothkopf and Bisbicos (1966) conducted a study in which they attempted to determine whether the use of restrictive categories of questions incorporated in written instructional material facilitate learning of restricted categories of text content. The questions were divided into two subsets and used either before or after reading to measure how much the subjects learned. In situations where the experimental questions appeared after exposure to the text, better overall retention test performance resulted than when the experimental questions appeared before the relevant text.

Snavely (1961) attempted to measure the effectiveness of purpose statements, and marginal notes as aids to reading comprehension. She tried to determine if these devices were of value in helping students to organize and comprehend material which they read in terms of main ideas, details, and generalization. The results

of the study indicate that none of the organizational treatments was significant in improving the comprehension level of the material read.

Smith (1966) conducted a study to determine the effectiveness of direct, planned instruction in reading for students who did not adapt their reading to purposes related to details, main idea, comparison and contrast, sequence, cause and effect, generalization, anticipation of outcome, sensory imagery, mood, characterization, and fact and opinion. Those who received the instruction gained more in reading and in identifying appropriate purposes for reading than did those who were subjected to incidental procedures.

Content Areas - Comprehension Needs

Mathematics and Reading Comprehension

How to teach students to solve word problems in mathematics is often a topic of discussion at meetings of mathematics teachers. In an effort to collect data which might suggest areas for curriculum revision and improvement, a study was conducted by Wiggin and Call (1966). The purpose of the study was to determine whether there is some correlation between a student's ability to solve word problems in second-year algebra and the presence or absence of special reading instruction. Two groups were taught the same unit in second-year algebra, a unit involving linear equations and word problems. The control group was taught by an experienced mathematics teacher. The experimental group was taught by an English teacher with a limited amount of training in the teaching of reading and with no training in the teaching of mathematics. The major difference in instructional techniques was the fact that the experimental group was taught to get meaning from words and translate it into mathematical symbols. This was done more in the manner of the teaching of reading than that of the teaching of mathematics. The following inferences were made from the data: 1) there is

some merit in teaching special reading skills for the solution of mathematical problems; 2) even very good readers, as measured by the Cooperative Reading Test, have difficulty in the interpretation of the kind of reading found in word problems; 3) if by teaching reading instead of mathematics we can get better results, it seems reasonable to infer that the competent mathematics teacher might get considerably better results if he were trained to teach reading of the kind encountered in mathematics.

The readability of difficult algebra textbooks was studied by Kulm (1973) to determine sources of reading difficulty. Two types of written materials were identified in algebra texts either as "explanatory" where concepts are defined, explained and developed, or as "illustrative" where specific examples of a problem or equation are provided. Data secured from the use of the "cloze" procedure disclosed no differences in readability for the two types of written materials. However, the variable of mathematical symbols was found to rank as the best single predictor of readability.

Glennon and Callahan (1968), after reviewing a number of studies on research in problem solving, concluded that the following factors were important for success in mathematics: 1) general reading skills, including vocabulary; 2) problem-solving reading skills, including comprehension of the problem statement, selection of relevant details, and selection of the proper solution procedure.

Science and Reading Comprehension

Science content reflects many vocabulary problems and researchers have explored ways of overcoming them.

Aldridge and Anderson (1960) found that science reading was related most intensely to abilities in word usage. Yet, science textbooks seemingly have provided their readers with insufficient aids to cope with the problem of vocabulary.

Science and Reading Comprehension (cont)

In a study summarizing the findings of several pieces of research dealing with problems in reading science, Lockwood (1959) found that: 1) there is insufficient provision in such textbooks of science for repetition of difficult scientific terms and nontechnical words; 2) too large a percentage of the difficult words are nontechnical words; 3) too small a percentage of the scientific terms that are introduced into such textbooks of science are defined: 4) the definitions of scientific terms fail to appear in the textbooks until the terms have been used extensively in earlier parts of the books.

Social Studies and Reading Comprehension

Research identifying reading skills necessary for achievement in the social studies has been inconclusive. However, it has provided some ideas concerning problems in reading social studies materials and skill needs.

Krantz (1957) correlated subscores from the Iowa Test of Basic Skills (a measure of reading achievement) of seventh graders with the subscores of these same students at the ninth-grade level and at the eleventh-grade level on the Iowa Tests of Educational Development (a measure of content area achievement) to determine the best predictors of social studies achievement. He concluded that graphs, reading vocabulary, and reading comprehension were the best predictors of success in the social studies.

Melvin Michaels (1965) isolated skills on the basis of difficulties students reported they had reading American history texts. In summary, these students reported difficulty in the use of references, comprehension, and readiness.

Instruction in skills such as defining the problem, understanding key words, interpreting pictures, graphs, and legends, reading maps, and drawing conclusions has been found to improve students' reading of social studies materials (Hilsop, 1961).

Social Studies and Reading Comprehension (cont)

Herber (1961) found that instruction in basic reading skills enhanced knowledge of the social studies content as well as reading skills. Herber's approach was to integrate skill instruction with the content. Vocabulary exercises were designed to provide practice in comprehension and study skills. Gains of those tested exceeded gains made by similar pupils in past years in the same school district.

English and Reading Comprehension

Of the content areas, the category of material we call "literature" appears to be the most difficult to comprehend. This difficulty was noted in a study by Galloway (1973). The ability of students was compared by Galloway with the ability of teachers to read subject textbooks. Selections from literature proved consistently harder for both students and teachers than selections from the other subject areas.

Research has been conducted analyzing content area materials to identify the various patterns of writing incorporated within them. These special writing patterns indicate the ways in which the subject specialist wants students to think in his particular field.

Smith (1964) analyzed widely used textbooks covering grades 7-12: 45 literature texts, 52 science texts, 60 social studies texts, and 49 mathematics texts in which she identified certain patterns of writing indicative of the various content areas. In literature, they are the story, essay, drama, biography, fable, and poetry. The patterns of writing in science are classification, explanation of a technical process, detailed statements of facts, problem solving, and abbreviations and equations. The identified social studies patterns are picture and map, cause and effect, sequential events, comparison, detailed statements of facts, and

propaganda. Patterns in mathematics are the problem, explanatory, graph and chart, and special symbols.

Smith found that the patterns of writing in the content areas are not mutually exclusive. The patterns utilized in the content of a given area require a different reading approach which is determined by the purpose of the selection and its written form.

In terms of the literature area, Smith found that different combinations of the common reading skills, with heavy emphasis upon interpretations, serve a student well.

Summary of Research

General Comprehension-Components

An analysis of pertinent secondary research on factors affecting reading comprehension resulted in the following conclusions:

1. The relationship between knowing multiple meanings of words and reading comprehension was found to be substantial. Students who were taught through a direct experience approach to vocabulary development showed an increase in reading achievement.
2. Research on sentence structure as a factor affecting reading comprehension revealed that there was a significant relationship between student knowledge of the use of grammatical and paragraph structure and the ability to comprehend main ideas in reading.
3. The bulk of the research studies on rate of reading as a factor affecting reading comprehension indicates that the purpose for reading, relevance of the question, and the background of experience influenced the student's rate of reading.
4. Most of the studies on questioning and purpose setting as factors affecting reading comprehension showed that questions placed at the end of the passage

to be read created a better effect upon the retention. Questions which were placed after paragraphs had both a specific and general facilitative effect on reading comprehension. Students who received direct instruction in reading for specific purposes, e.g., cause and effect, made significant gains in reading and identifying appropriate purposes. Organizational aids incorporated in the reading material did not cause the reader to attain a higher level of reading comprehension.

Content Areas - Comprehension Needs

The research findings pertaining to Mathematics, Science, Social Studies, and Literature and their relationship to the components of reading comprehension are summarized in the following paragraphs.

1. Vocabulary - Students taught to get the meaning from words and translate that meaning into mathematical symbols achieve at a significantly higher level on word problems. Achievement in science relates to the difficulty of the technical and nontechnical vocabularies used to present the concepts. These problems are compounded by a paucity of author defined terms. In social studies, understanding key words was identified as a major contributing factor to achievement. The importance of word meanings was also emphasized in the study of literature.
2. Sentence/Paragraph Structure - In mathematics, no difference was noted in the readability of texts using an explanatory writing style compared with the illustrative style. The successful reading of science is more closely related to word usage than grammar usage. Students in the social studies reported that an area of needed instruction for them was selecting main ideas. In literature, the student needs to be familiar with the patterns utilized in various types of writing.

3. Purpose and Rate - The purpose for reading determines to a great extent how quickly material will be read. The sophistication of the problem solving reading skills in mathematics all play a part in determining speed. Although the purpose for reading a selection in science will determine how quickly it will be read, the frequency of difficult nonscientific and nontechnical words will also affect the rate of reading. In social studies, readiness for reading affects the success with which students accomplish the purpose of the assignment and the speed with which it can be completed. The ways in which the author of a literary work wants his readers to think about his particular topic and/or purposes, will determine to a great extent, the rate of speed with which it will be read.

In general, it will be noted that the skills identified as needed in one content area are found in others also (Beard, 1967). The uniqueness of skills to a given area lies in the adaptation by the teacher to meet the special needs of his discipline.

Translating Research Into Classroom Practice

The suggestions that follow are a resource for teachers to use in promoting reading comprehension. These lesson prototypes are intended to convey strategies by which the research findings presented earlier can be implemented in the content areas.

TECHNIQUES FOR DEVELOPING VOCABULARY

Experience

-Direct manipulation of concrete objects, e.g., auto parts, tools, rock samples, can lead to the labeling of objects for mounting or display and the writing of brief descriptive statements concerning object appearance, safety features, or use.

-Interpreting and developing graphs, charts, tables, maps, and diagrams.

-Logs, e.g., science experiments and interviews, which put into printed form the specialized vocabulary expressed orally as a prelude to reading assignments utilizing these same terms.

Multiple Meanings

-Write the numbers of the correct dictionary definitions for underlined words in context.

Example: His movements were deliberate as he picked up the glove.

It had been a deliberate attempt on his life.

The problem was one he would have to deliberate.

Structure

-Emphasize the recognition of roots, prefixes, and suffixes.

-Provide the meaning and root, prefix or suffix. Have the student identify the word.

Example: An organism living in or on another. Prefix (para) (parasite)

A killing of one human being by another. Root (homo) (homicide)

The number that is to be multiplied by another. Suffix (and) (multiplicand)

Synonyms and Antonyms

-Use synonyms as substituted for new vocabulary in context.

Example: The plane ascended to a height of seven thousand feet.

a. dove b. climbed c. swerved

-Contrast words with their opposites or antonyms.

Example: Choose a word from the following which means the opposite of frugal:

a. stingy b. tight c. extravagant

Figurative Expressions

-Provide practice with figurative language, expressing one thing in terms normally denoting another.

Example: He pushed the bucket-of-bolts into the yard. Then be borrowed his father's wheels.

a. A metal bucket filled with bolts was pushed into the yard.

b. An old worn-out car was pushed into the yard.

Context Clues

-Encourage the use of the context in which a "new" word is embedded to arrive at the author's meaning. Synonyms, definitions, explanations, comparisons, and experience are employed for this purpose.

Example: Some of the smallest sea animals of all are the larvae, or young. (synonym)

The feeding grounds of some fish are in water two or three fathoms deep. (A fathom is a measure of water depth; it equals six feet.) (definition)

When he wants to move fast, the squid uses his own method of jet propulsion by sucking water into a cavity through a hole in this head. Then, by using certain muscles, he squeezes this water out quickly. The jet of water this creates moves the squid rapidly backward. The

jet is so powerful that it has caused some squids to zoom right out of the water and pop onto the decks of ships. (explanation)

Example: Some of the smallest sea animals . . . feed on diatoms. Diatoms are tiny plants. Through a microscope, they look like crystals of different shapes and colors, all very beautiful. The diatoms float on the surface of the sea because, like most other plants, they need the sun in order to live. (comparison)

Example: It was a tie score. The home team's cheerleaders ran onto the field shouting, "Locomotive"! The fans rose and joined the cheerleaders in shouting, "We want a touchdown". (experience)

Abbreviations and Equations

-Have students translate mathematical symbols into words and words into symbols to improve comprehension.

Example: $d = v\ t$ (d = distance, v = velocity, and t = time)

At 60 (v) miles per hour, how far (d) can a car travel in a 20 (t)-minute time slot? _____ (1/3 of an hour)

how far

↓

$d = 60 \times 1/3$

Example: Which of the following words mean the same as each letter in the formula: (cross out the words that don't belong)

d	=	v	•	t
moving		speed		how long
average		volume		hours
distance covered		velocity		minutes
traveled		momentum		card

Technical Terms

-The use of analogies or relationships may help students discover the meaning of technical terms.

Technical Terms (cont)

Example: Complete the following analogies:

botony - zoology: chlorophyll _____

(plasma, villi, fertilization)

water - sonar: air _____

(friction, ultrasonic, numbers)

Example: Circle the word from the choices on the right that has something in common with the words on the left.

anchor	potent
secure	stable
	deviation

Key Words

Some words used in questions give clues to the priorities the author has placed upon the ideas he wants to stress in his material.

-Check key words following the questions which you think will help you find the answers in the assignment:

Example: What is the difference between lymph and plasma? (no more than three key words) --What --difference --lymph --plasma

How does the pituitary gland control other endocrine glands? (no more than two key words) --pituitary --gland --control --other

Techniques For Developing Awareness Of Sentence And Paragraph Structure

Syntax

-Practice in noting the ways in which words are used, position or arrangement within a sentence, helps to indicate the function of a word, and therefore, an aspect of its meaning.

Example: Select the appropriate association for the underlined word by noting its position or use in each sentence. (Use letters to indicate your

choice)

___ 1. It was a minute organism.

___ 2. The minute was used for preparation.

a. names something, the topic or main thought

b. describes or qualifies something

-Promote word selection and aspects of meaning, by anticipating relationships developed through other words in the sentence. The cloze procedure developed by Bormuth (1968) can be used for this purpose.

Example: Fill in the blanks with the words you think will complete each thought. (Note: Every tenth word has been deleted. Accept synonyms or grammatically correct substitutions for deleted words. Scores of 40% and more indicate that for a given student the material is suitable for instructional purposes.)

The first watchers of the sky notice that five _____ stars changed their positions from night to night, drifting _____ apparently capricious paths. The Greeks named them planetai, the _____. Today we know that they are not stars, but _____ companions of the sun, like the Earth, shining by _____ light.

Clause Structure

Example: Cross out the clause, a group of words, that is unnecessary in a sentence.

The neutron, as its name implies, carries no electircity, but weighs slightly more than the proton.

Example: Circle the relative clause which depends on another word or words for its meaning:

The man who wanted it is gone.

a. The man

b. who wanted it

c. is gone

Clause Structure (cont)

-Noting pronouns and their referents will aid in unifying the ideas presented in the individual sentences of a paragraph.

Example: Read the following article about Centipedes paying close attention to the numbered words. These words have been written in a column followed by blanks. Write the word to which the number refers on the blank.

The ordinary house centipeded, scuttling to save himself[1] in the cellar, looks like a set of whiskey eyelashes. His[2] name means "a hundred legs", though he[3] has only about 60.[4]

1. himself _____
2. His _____
3. he _____
4. 60 _____

Identifying Main Ideas

-Select paragraphs from the student's textbook and provide three topic sentences for each one. Have students select the best topic sentence for each paragraph. (When initiating this procedure, use the exact words of the correct topic sentence. Later, paraphrase the correct topic sentence.)

-Provide several details from a given textbook paragraph and have students write a topic sentence for each.

-Have students organize sentences under selected paragraph headings.

Example: Place the following sentence numbers under the appropriate topic:

	Farming	Mining
1. After a while farmers began to irrigate.	_____	_____
2. Mining is one of the most important industries in Montana.	_____	_____
3. They found that the soil is rich and only needed water to produce good crops.	_____	_____

Location of Main Ideas

-The location of the main idea can depend upon a writer's style, sophistication of material, and the content area. Direct student attention to the following main idea locations within the structure of a paragraph:

Example: First Sentence -

The sun's extremely high temperatures indicate that it is made up entirely of gases. No solids or liquids can exist even at the lowest temperatures found in the sun.

Last Sentence -

Each Indian tribe speaks its own dialect. Indians rarely marry outside of their village. In many villages the land is held in common. It may be said that every Indian village is a little world to itself.

Middle Sentence -

Though the citizens of Athens were set free from much of the drudgery of life, because of slavery we must not get the idea that they reveled in luxury. "Plain living and high thinking" was the Greek motto. The standard of confort was really very low in comparison with our own.

Summary paragraph - restates and reinforces the essential ideas in preceding material.

Up to this point in the discussion, you have noted that the mines of the Mesabi, and neighboring areas in northern Minnesota, produced 80% or more of the iron ore mined in the United States. The high-grade ores of this so called Lake Superior district may be entirely mined out within the next twenty years. Fortunately, Venezuela and Canada have large reserves of rich iron ore which have scarcely been scratched. In the future, the iron and steel industries of the United States will doubtless draw more and more heavily on these deposits of its neighbors.

Patterns of Writing

Patterns of writing indicate the ways in which the subject specialist wants students to think in his particular field.

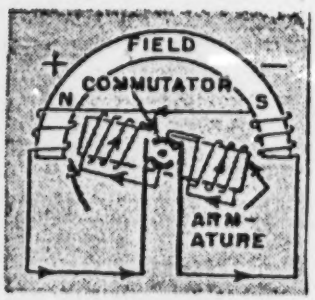
-Classification

Igneous rocks are those formed by the cooling and hardening of hot molten rock from within the earth's crust. Sedimentary rocks are those formed by the accumulation and hardening of sediments. The sediments may consist of rock fragments, plant and animal remains, or chemicals precipitated from solution. Metamorphic rocks are formed when rocks that already exist are transformed directly into new kinds of rock. The solidified lava of a volcano is igneous; sandstone, formed of sand, is sedimentary; and marble, derived from the transformation of limestone, is a metamorphic rock.

Fill out the table below. Write the name of each type of rock, tell how it was formed, and give examples.

Type of Rock	Formed By	Examples

-Explanation of a Technical Process



An electric motor is simply a spinning magnet. A movable magnet swings around because its north pole is repelled and its south pole is attracted by the pole of the fixed magnet. It will stop turning when its south pole if nearest the north pole of the fixed magnet.

Now suppose that just as the S pole of the movable magnet nears the N pole of the fixed magnet, we could in some magical way suddenly reverse its magnetic poles. Then it would keep moving for another half turn. If we could change its poles every half turn, the moving magnet would spin around and around.

We can't do this, but we can do even better. In place of the movable bar magnet, we can use a coil of wire wrapped around an iron core--an electromagnet which revolves.

Place the following statements in the order (number them) in which they occurred in the explanation:

____ In place of a movable bar magnet, we can use a coil of wire wrapped around an iron core.

____ If we could change its poles every half turn, the moving magnet would spin around and around.

Detailed Statements of Facts

In science, this pattern differs from text in other subjects because the facts are more dense, and they are frequently directed towards a definition or principle.

Example: Read the following paragraph and answer the questions below:

(1) Plants, obviously, have no organs with which they can pump air in and out of their bodies. (2) The molecules of oxygen diffuse in through stomata, tiny pores in the leaves. (3) The bark of trees and shrubs also has pores that permit oxygen to diffuse through the cork-like layers that protect the stem. (4) These pores are called lenticals. (5) They make it possible for living cells beneath the cork to get oxygen.

1. Plants breathe through the use of organs in the same way as animals. Use sentence numbers to prove this statement true or false.

2. Tiny pores in leaves called _____ permit oxygen to enter.

Problem Solving

The description of a problem-solving situation usually involves a series of experiments. Emphasis is directed towards identifying each problem in succession and how it was met. Example:

(1) The weightless or zero-g condition could not be duplicated on the gound. (2) Some experts, however, of the U.S. Air Force's Department of Space Medicine discovered a way of producing zero-g in flight. (3) They

took a fast plane, a jet trainer, and put it into a power dive to gather speed. (4) Then they pulled the nose of the plane up and cut the engine at the same time. (5) This made the plane go through an arc like a hurled stone, and until the engine was started again everything in the cabin was weightless. (6) The drawback was that this weightless arc could not be made to last longer than a half minute. (7) A faster plane was needed. (8) The plane which could extend the period of weightlessness from a half minute to about six minutes is the X-15.

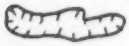
To identify problem statements, skim for key words which are negative in connotation, e.g., not, no, drawback. Circle the numbers of the problem statements. List the sentence numbers which indicate the solving of problems on the line below.

_____

Maps and Pictures

Maps, atlases, and globes require the use and interpretation of symbols.

Example: Draw a line from the symbol to its meaning:

Symbol	Meaning
	Point of Interest
	Depression
	Mountain Pass
	Ancient Historical Site
	Fort

Cause and Effect

In developing cause/effect relationships, words such as consequently, result, and because help to pinpoint the related conditions.

Example: Using the following lines of print (1, 5), circle the key words which indicate the cause/effect pattern:

Warning causes convection. This produces cumulus clouds, windiness, and generally good visibility. If the warming is considerable and enough moisture is present, as when the warm surface beneath is a lake or ocean, the cumulus clouds may grow into cumulonimbus, and showers or thunderstorms may result.

Sequential Events

Dates, numbers, and words like first, later, and before, can direct the student's thinking toward a sequence of events.

Example: Write the words, dates, or numbers which suggest a sequence of events in the following story:

> Early in February, 1943, a series of slight earthquake shocks disturbed the residents in and near the village of Particutin, a farming community. For weeks the shocks continued, until on February 20, a number of cracks appeared in a perfectly level corn field, hardly more than a mile from the village. Fiercely hot gases escaped into the air, and were soon followed by blasts that shattered the earth and opened outlets through which lava and cinders were ejected. Eruptions and earthquakes continued to rock the area, and in May the volcano became so violent that it was necessary to evacuate the residents for many miles around.

Line	Word Date Number
1	_____
4	_____
8	_____

Comparison and Contrast

Discussion of likenesses and differences concerning two or more items or issues are indicative of the comparison and contrast pattern.

Example: Check words or phrases from the list below which bring a comparison and contrast to mind. Then read the paragraph and number the lines of print containing the words you checked. (___ same, ___ finally, ___ correspond, and ___ related)

Line

___ The length of a day on Mars is nearly the same as ours, and its
___ year and seasons are about twice as long. The green color of its
___ spring-time and the browner color of its fall season seem to
___ correspond to the seasonal blooming and withering of vegatation
___ on the earth.

Propaganda Patterns

Although sometimes used for worthwhile causes, propaganda is more often misused for personal motives.

Propaganda Patterns (cont)

Example: Types of propaganda and their explanations are listed on the left. Identify the examples with the appropriate propaganda label.

Bad Names (disagreeable words)

Glad Names (pleasant terms desirable qualities)

Transfer (shift admiration from a person to a product or behavior)

Testimonial (recommending the product by a famous personality)

Plain Folks (humble, common people underneath)

Band Wagon (everyone else is using it)

1. "All the girls are buying contact lenses instead of glasses". _____

2. Defole can salvage your weed filled, dying lawn overnight. _____

Problem Pattern

In mathematics, problems are usually stated in terms of the following components: a situation; a series of numbers; and what is to be found.

-Have student underline (one line) that portion of the word problem which describes the situation. Underline (two lines) the portion which tells what is to be found.

-Write a series of questions about a problem. Have students answer the questions prior to calling for the quantitative solution.

Example: Find two consecutive odd integers such that the square of the second, decreased by the first is 22.

1. What does consecutive mean?
2. What does decreased mean?
3. Which of the following is not an odd integer: 1, 3, 5, 7, 8. Circle it.
4. Why would x + 2 equal the second integer?

-Write or solve problems that contain an error, e.g., logic, formula, integer. Have students identify the error and correct it. Then solve the problem.

Techniques For Identifying Purposes And Rate Of Reading

The purpose for reading determines to a great extent how quickly material will be read. For example, a summary or overview of an assignment to note its organization and general theme will take less time than reading to solve a specific problem.

-Encourage students to convert major heading into organizational questions as they read each subdivision of their assignment by placing words like who, what, where, when, why, and how before the topic heading.

-Require students to make up their own questions based on a survey of an assignment. (Survey heading, captions, first sentence of each paragraph, and read all of the last paragraph.) These questions can be used as the basis for class discussion prior to reading the assignment.

-Give students a general statement and ask them to list justifications for the statement from the text.

-Have students convert the introductory paragraph of the assignment into a series of questions. Then find answers to the questions formulated.

-Provide the class with a problem and require them to read an assignment to find a solution. This problem should deal with something implied in the lesson.

-Have students skim to identify and list the organizational patterns found in an assignment using key words, e.g., because, as a result, like, differs, then, next, etc.

-Give students a false generalization and have them evaluate it in terms of the information given in the text.

-Select several paragraphs from a selection and give them to students out of order. Have students read the text assignment to sequence the paragraphs.

Techniques For Facilitating Comprehension - The Teacher

The meaningful application of the following techniques is heavily dependent, at least initially, upon the teacher as he guides students towards independent learning through demonstration and the application of the lesson components involved.

SQ3R (Robinson, 1961, p. 198) has implications for general use in most content subject areas.

> -The SQ3R method . . . consists of five steps: (1) "Survey" the heading and summarize quickly to get the general ideas which will be developed in the assignment, (2) turn the first heading into a "Question", (3) "Read" the whole section through to answer that question, (4) at the end of the headed section stop to "Recite" from memory on the question and jot the answer down in phrases, (Step 2, 3, and 4 are repeated on each succeeding headed section), and (5) at the end of reading the assignment in this manner then immediately "Review" the lesson to organize the ideas and recite on the various points to fix them in mind. (Robinson, Francis P., Effective Study (Rev. Ed) New York: Harper & Row, Pub., 1961).

Profundity Scale (Andresen, 1966) is designed to afford students and teacher with a way to discover and evaluate the depth of an author's themes in a literary work. The scale is on five planes: physical, mental, moral, psychological, and philosophical.

Example: The following examples are taken from the book, "The Light In The Forest" by Conrad Richter.

> Physical Plane: Reader awareness of the physical actions of the characters. (The attack of the Delaware Indians upon the farmers harvesting crops in western Pennsylvania and the abduction of John.)
>
> Mental Plane: Reader awareness of the physical and intellectual actions of the characters. (Parson Elder's conversation with True Son over the Conestoga massacre and Elder's roles in it as both a parson and a colonel.)
>
> Moral Plane: Reader awareness of the physical and intellectual actions of characters in light of an ethical code. (When the braves went on the warpath to avenge the cold-blooded murder of one of their tribe by a white man, True Son was supposed to lure a large party of whites into an ambush. At the last moment, John warned the occupants of the river boat that the Indians were lying in ambush.)

Psychological Plane: Reader is aware of the psychological forces influencing the characters physical and intellectual actions in light of an ethical code. (After eleven years with the Indians, John was returned to the Butler family, but he ran away when he could not adjust to this new life.)

Philosophical Plane: Reader is aware of the universal truths expounded by the author through the physical, intellectual, and ethical behavior of the characters under the influence of psychological forces. (The Indians' side of the story is presented by the author so that modern man might better understand that the Indian once enjoyed far more than he.)

Cue Sheets (Smith, 1972, p. 171) are suggested for use by science teachers to help students approach the reading of content materials.

I. Vocabulary Cues

A. There are certain words and related concepts that all pupils should know in order to read almost any science material above the primary level.

1. An understanding of basic descriptive terminology such as things in common, characteristics, various, classified, and similarities is quite helpful in comprehending the data that follow the terms.

2. Knowledge of common Latin or Greek roots or other derivations, e.g., hydro, electro, photo, un, bi, etc., facilitates understanding of new but related scientific vocabulary.

B. Every new science lesson requires the teaching of terms pertinent to that selection.

II. Typographical Cues

A. Typographical cues are especially important in the first survey reading, because they offer brief but obvious identification content.

B. Most science textbooks include typographical cues such as good subtitles, chapter headings, summaries, outlines, underlining or italicizing, indexes, glossaries, tables of contents, pictures, graphs, and charts.

III. Search Cues

A. Certain procedures provide the general information sought from a preliminary survey of the material.

1. Attention should be given to pictures.
2. The organization of the content as it is reflected in the main headings and subheadings should be noted.
3. The first paragraph and the summary, if given, should be read.
4. Questions to be answered while reading should be formulated from the survey.

B. Other reading skills are needed to carefully search out specific information such as that required to answer the formulated questions.

1. Careful attention to and analysis of facts and objective data are essential.
2. Critical reading to determine the criteria for evaluating the content is necessary.

C. The ability to determine <u>exactly</u> what information is contained in the material is essential in reading science.

1. A thorough discussion and evaluation of the reading is probably the the best method to determine and insure accurate interpretation.
2. Precision in reading is vital. Pupils should be urged to report exactly what they have read. For example, they must be aware of qualifying terms such as those identified in the following sentences:
   a. <u>Most</u> kinds of bats are useful to mankind because they eat harmful insects.
   b. <u>Some</u> scientists believe there is life on Mars.

IV. Organizational Cues

The most common organizational approaches used in science selections are deductive and inductive.

A. Deductive

1. Generalizations are given first.

2. The subject is classified.

   a. General characteristics are given.

   b. Differences and similarities among the classes are noted.

3. Examples and supporting data giving specific information about differences within the classes follow the classifications.

4. Rewrite:

   a. Rewrite algebraic facts in terms of a "balanced" equation and then solve for x:

$$4x - (x + 2) = 12 + 2(x + 4)$$
$$=$$
$$=$$
$$x = 22$$

5. Review:

   a. Substitute value of x in equation to check for true sentence:

   Check: $4(22) - (22 + 2) = 12 + 2(22 + 4)$

   b. Does the problem make sense in terms of the question? 22, 24, and 26 are 3 consecutive even integers such that . . .

B. Inductive

1. The data are given first

2. Then the science writer builds up to classifying

3. Generalizations come last

V. Special Considerations

A. Science students must be able to read symbols, e.g., (AuH_2)--gold-water.

B. They must be able to follow diagrams. For example, a student must understand the idea of completeness, as in an electrical circuit or a chemical

equation. A diagram of an electric circuit when accompanied by explanatory text is an example of what the teacher can use to demonstrate that a diagram oftentimes can give a picture of the complete idea. The text then becomes more comprehensible.

PQ4R (Maffei, 1973, p. 547-549) is a technique applied to word problems in mathematics. The device provides an outline structure for setting up problems in comprehensible units.

Example: Problem: Find 3 consecutive even integers such that 4 times the first decreased by the second is 12 more than twice the third.

1. Preview:
   a. First reading of problem
   b. List unknown words and phrases for possible discussion
      1) consecutive
      2) even
      3) integers
2. Question:
   a. Second reading
   b. Write direct question of problem:
      Find 3 consecutive even integers
3. Read:
   a. Third reading
   b. List all word facts of problems in some logical order
      1) 4 times the first
      2) decreased by the second
      3) is 12 more than
      4) twice the third

4. Reflect:

   a. Fourth reading

   b. What is x the unknown quantity representing?

      Let x = 1st consecutive even integer: x, 2 + 2, x + 4

   c. Translate word facts into algebraic facts with the use of x.

      1) 4(x)

      2) -(x + 2)

      3) = 12 +

      4) 2(x + 4)

5. Rewrite:

   a. Rewrite algebraic facts in terms of a "balanced" equation and then solve for x:

$$4X - (x + 2) = 12 + 2(x + 4)$$
$$=$$
$$=$$
$$x = 22$$

6. Review:

   a. Substitute value of x in equation to check for true sentence:

      Check: $4(22) - (22 + 2) = 12 + 2(22 + 4)$

   b. Does the problem make sense in terms of the question? 22, 24, and 26 are 3 consecutive even integers such that . . .

Conclusion

Content demands and the teacher's understanding of the reading task, from a reader's point of view, will determine the skills needed to promote comprehension in a given assignment. The utilization of lesson strategies, such as those just presented, promote skill development and enhance the comprehension of content material simultaneously.

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